



E-ISSN: 2320-7078

P-ISSN: 2349-6800

JEZS 2015; 3 (1): 182-192

© 2015 JEZS

Received: 16-12-2014

Accepted: 12-01-2015

Dharitri Choudhury

*Ph.D. Research Scholar,
Department of Ecology &
Environmental Science, Assam
University, Silchar, India-788011*

Susmita Gupta

*Associate Professor, Department of
Ecology & Environmental Science,
Assam University, Silchar, India-
788011*

Aquatic insect community of Deepor beel (Ramsar site), Assam, India

Dharitri Choudhury, Susmita Gupta

Abstract

An investigation on the aquatic insect community of 10 selected sites of Deepor beel, the only Ramsar site of Assam situated on the southern side of River Brahmaputra was carried out during the month of March to November, 2013. During the study period aquatic insect community was represented by 31 species belonging to 18 families of 5 orders. Record of 17 species and 8 families of the order Hemiptera showed that it is the largest order in terms of aquatic insect diversity followed by order Coleoptera having 7 species and 5 families.

Keywords: Deepor beel, Hemiptera, Coleoptera, aquatic insect diversity.

1. Introduction

Aquatic insects play an important role in aquatic ecosystem functioning [1]. They are an important component of invertebrate assemblages in aquatic ecosystem where they are a controlling group in food webs. At the larval stage, they constitute the principal nutritive fauna of fish [2, 3].

India is one of the mega-biodiversity countries in the world [4]. Although, the northeastern region of India was identified as a biodiversity hotspot by the World Conservation Monitoring Centre [5], the aquatic insect fauna of this part of India is rather poorly documented. Compared to the studies on the diversity of aquatic insects in peninsular India, [6, 7, 8, 9, 10, 11, 12, 13, 14, 17], studies in North-east India are fewer [18, 19, 20, 21, 22, 23, 24, 25, 26]. Deepor beel the only Ramsar site of Assam has not been thoroughly investigated for aquatic insect diversity and density besides a few studies [27, 28]. It was included in the Directory of Asian wetlands [29] and the Government of Assam has declared Deepor beel as a wildlife sanctuary in 1989 [30]. The wetland has been included in the list of Ramsar sites in November, 2002. It is considered as one of the staging sites for migratory birds in India and included in the list of Important Bird Areas (IBA) by Birdlife International since 2004 [31]. In this context, this study will contribute towards the knowledge of species diversity and taxonomy of aquatic insects of Deepor beel.

2. Materials and Methods

The study was carried out during March to November, 2013 from 10 selected sites of Deepor beel (Long 91° 35' E to 91° 43' E, Lat 26° 05' N to 26° 11' N) (Fig. 1). Located about 10 km southwest of Guwahati city it is considered as one of the large and important riverine wetlands in the Brahmaputra valley of lower Assam, India and provides livelihoods to the inhabitants.

Aquatic insects were collected from the selected sites by 'Kick' method [32] using a net of mesh size 500 µm whereby the vegetation was disturbed and the net was dragged around the vegetation for a unit of time [33]. Three such drags constituted a sample. Three replicate samples were collected and the insects were then sorted, counted and then preserved in 70% ethyl alcohol. They were later identified using Motic Stereo Zoom Microscope (SMZ-168) with the help of standard keys [34, 35, 36, 37, 38, 39, 40, 41, 42, 43].

Correspondence:

Susmita Gupta,

*Associate Professor,
Dept. of Ecology &
Environmental Science,
Assam University, Silchar,
788011, Assam, India*

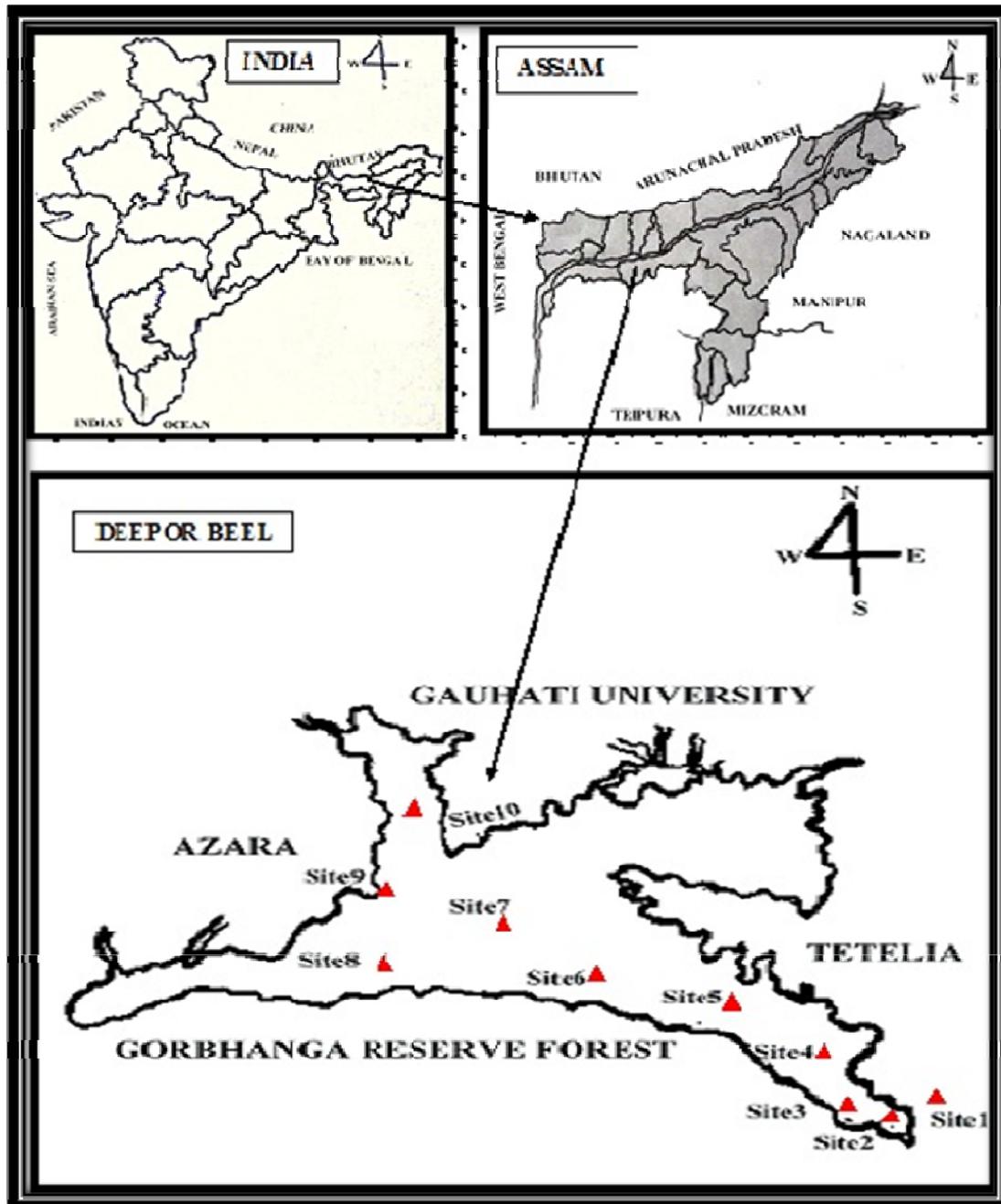


Fig 1: Map showing India, Assam and different selected sites of Deepor beel

3. Results and Discussion

The present study recorded 5 orders of aquatic insects (Hemiptera, Diptera, Coleoptera, Odonata, Ephemeroptera), 18 families (Corixidae, Nepidae, Mesoveliidae, Notonectidae, Gerridae, Pleidae, Veliidae, Belostomatidae of the order Hemiptera; Libellulidae, Coenagrionidae of order Odonata; Hydrophilidae, Dytiscidae, Chrysomelidae, Gyrinidae, Curculionidae of order Coleoptera; Baetidae of order Ephemeroptera; Chironomidae and Culicidae of order Diptera), 26 genera and 31 species. They were represented by 17 species of order Hemiptera, 7 species of order Coleoptera, 4 species of order Odonata, 2 species of order Diptera and 1 species of order Ephemeroptera (Table 1). The number of species recorded in the present investigation exceeded the findings of Chetri *et al.* [27] from the same beel. It was found that the number of species of order Hemiptera was recorded

highest (17) followed by order Coleoptera (7). Deepa and Rao [44] recorded eight *Heteropteran* from Pocharam Lake, Andhra Pradesh; Bhattacharya [45] described eight species in association with *Eichhornia crassipes* in some freshwater wetlands of West Bengal; Khan [46] recorded eight species from two man-made lakes of Kolkata; Hazarika and Goswami [21] recorded 14 species from two pond ecosystems in Gauhati University, Assam; while Das and Gupta [19] recorded 12 species of Hemiptera from rain pools and 10 species of Hemiptera from agricultural fields in Cachar district, Assam. Similarly, Das and Gupta [20] recorded 14 species of Hemiptera from a temple pond in Cachar district, Assam and Gupta and Narzary [25] recorded 5 species of Hemiptera from Phulbari anua, Assam. The number of recorded species in the present study signifies the rich diversity of aquatic insects in the only Ramsar site of Assam.

Table 1: List of aquatic insects recorded in Deepor beel during the study period.

Order/ Family	Species	Order/ Family	Species
Hemiptera	<i>Micronecta siva</i> (Kirkaldy, 1897)	Coleoptera	<i>Laccophilus</i> sp. (Leach, 1817)
Corixidae	<i>Micronecta haliploides</i> (Horvath, 1904)	Dytiscidae	<i>Berosus</i> sp. (Leach, 1817)
Pleidae	<i>Paraplea frontalis</i> (Fieber, 1844)	Hydrophilidae	<i>Laccobius</i> sp. (Erichson, 1837)
	<i>Paraplea liturata</i> (Fieber, 1844)	Gyrinidae	<i>Dineutus</i> sp. (Macleay, 1825)
Notonectidae	<i>Anisops bouvieri</i> (Kirkaldy, 1904)	Curculionidae	<i>Sphenophorus</i> sp. (Schoenherr, 1838)
	<i>Anisops breddini</i> (Kirkaldy, 1901)		<i>Neochetina</i> sp. (Hustache, 1926)
	<i>Aphelonecta</i> sp. (Lansbury, 1965)	Chrysomelidae	<i>Donacia</i> sp. (Fabricius, 1775)
Mesoveliidae	<i>Mesovelia mulsanti</i> (White, 1879)	Odonata	<i>Leucorrhinia</i> sp. (Brittinger, 1850)
	<i>Mesovelia vittigera</i> (Horvath, 1895)	Libellulidae	<i>Neurothemis</i> sp. (Brauer, 1867)
Belostomatidae	<i>Diplonychus rusticus</i> (Fabricius, 1781)	Coenagrionidae	<i>Ischnura</i> sp. (Charpentier, 1840)
Nepidae	<i>Ranatra longipes longipes</i> (Stål, 1861)		<i>Pseudagrion</i> sp. (Selys, 1876)
	<i>Ranatra varipes</i> (Stål, 1861)	Ephemeroptera	<i>Cloeon</i> sp. (Leach, 1815)
	<i>Laccotraphes</i> sp. (Stål, 1865)	Baetidae	<i>Chironomus</i> sp. (Megien, 1803)
Gerridae	<i>Gerris</i> sp. (Fabricius, 1775)	Diptera	
	<i>Neogerris</i> sp. (Matsumura, 1913)	Chironomidae	
	<i>Limnogonus nitidus</i> (Myar, 1865)	Culicidae	<i>Culex</i> sp. (Linnaeus, 1758)
Veliidae	<i>Microvelia</i> sp. (Westwood, 1834)		

Systematic position and characters of aquatic insects recorded in Deepor beel

Kingdom- Animalia

Phylum-Arthropoda

Class- Insecta

Order- Hemiptera

Sub-order-Heteroptera

Infraorder- Nepomorpha (Aquatic bugs)

1. Family-Corixidae

Sub-family- Micronectinae

Genus-*Micronecta*

Species 1- *Micronecta siva* (Kirkaldy, 1897)

Diagnosis – Length of brachypterous 2.8-3.0, macropterous 2.7-3.4 mm. the macropterous form is a large elongate species with very distinct solid longitudinal stripes on the hemelytra and three transverse dark stripes on the pronotum. Lateral margins of the hemelytra with an unbroken brown stripe (Plate 1).

Distribution - India; Sri Lanka; South-East Asia; Sumatra; Burma; Thailand and Vietnam ^[47].

Species 2- *Micronecta haliploides* (Horvath, 1904)

Diagnosis – Length of brachypterous 2.4-2.9 mm, macropterous 2.6-3.3 mm. A large elongate oval to elongate species, immediately recognizable by the yellowish hemelytra

with distinct dark dots (Plate 1).

Distribution- India; Sri Lanka; South-East Asia; Sumatra;

Java; Bali; Singapore; Johor; Melaka; Negri Sembilan; Penang and Selangor and Kahang ^[47, 48, 49].

2. Family – Nepidae

Subfamily- Ranatrinae

Genus- *Ranatra* (Fabricius, 1790)

Species 1- *Ranatra longipes longipes* (Stål, 1861): Body length, 21-27 mm; length of respiratory siphon, 16- 22 mm; colouration medium brown. Head with vertex slightly raised above the eyes. Middle tibia longer than both middle and hind femora; hind tibia distinctly longer than the middle tibia (Plate 2).

Distribution-India; Java; Sumatra; Borneo; Peninsular Malaysia; Sulawesi ^[49, 50, 51, 52, 53, 54].

Species 2- *Ranatra varipes* (Stål, 1861): Body length of male 20–25 mm, length of respiratory siphon 16–19 mm; female body length 20–27 mm, length of respiratory siphon 15–19 mm. Colouration medium brown, femora mottled with light and dark brown. Head with vertex rounded. Ventral prothorax with a prominent medial longitudinal carina present along entire length. Fore femur short and thick, with a large broad, angular tooth near midpoint of the margin adjacent to the infolded tibia and a much smaller angular tooth slightly distal

to the midpoint on this same margin with the tibia resting between them when closed (Plate 2).

Distribution- Java; Singapur; Sumatra; Burma; Ceylon; India; Thailand; Peninsular Malaysia; Laos and Vietnam [43, 52].

Subfamily- Nepinae

Genus- *Laccotraphes* (Stål, 1865)

Species 1- *Laccotraphes* sp.: Body elongately sub-oval and flattened; pronotum about as long as a little shorter than broad. Hind coxae widely separated from each other; anterior femora a little incrassate and longitudinally grooved below; a round tubercle at the base of each anterior femora; anterior coxae very short (Plate 2).

Distribution- India; China; Taiwan; Japan; Nepal; Pakistan [38].

3. Family- Notonectidae

Subfamily- Anisopinae

Genus- *Anisops* (Spinola, 1837)

Species 1- *Anisops bouvieri* (Kirkaldy, 1904): Body length 7 mm, antennae three-segmented, interocular space anteriorly produced into a cephalic projection. Cephalic projection in dorsal view acuminate at apex, in lateral view extending in front of eye half or more the total length of the frons (Plate 1).

Distribution- India and Sri Lanka; Indochina, Malay Peninsula; Java and Sulawesi; Kedah; Melaka; Johor; Singapore; Negeri; Sembilan; Pahang; Perak and Selangor [49, 53, 55].

Species 2- *Anisops breddini* (Kirkaldy, 1901): Body length 7 mm, antennae three-segmented, interocular space anteriorly not produced into a cephalic projection. In dorsal view eyes holoptic in posterior half (Plate 1).

Distribution- India; Sri Lanka; Indochina; Java; Sulawesi; Malay Peninsula; Kedah; Melaka; Johor and Singapore [49, 53, 55].

Subfamily- Notonectinae

Genus- *Aphelonecta* sp. (Lansbury, 1965)

Species 1- *Aphelonecta* sp.: Hemelytral commissure without a definite hair-lined pit at anterior end. Mid femur without a pointed protuberance. Eyes basally widely spaced (Plate 1).

Distribution- South-East Asia [56].

4. Family- Pleidae

Genus- *Paraplea* (Esaki and China, 1928)

Species 1- *Paraplea frontalis* (Fieber, 1844): Larger species, length 2.0-2.4, pronotum is lacking the characteristic well defined dots at humeral angles and posterior margin, head pattern usually with one or two pairs of small spots dorsally in addition to the median stripe (Plate 1).

Distribution- India; Sri Lanka; Singapore; Sumatra; South-East Asia; Taiwan and the Moluccas [47, 49].

Species 2- *Paraplea liturata* (Fieber, 1844): Small species, length 1.3-1.7, pronotum characteristically with five small round black dots, one at each humeral angle, a median one near posterior margin and a pair more anteriorly near the median line. An additional ill defined pair medially of the

humeral spots may be present. Hemelytra typically with brown transverse bands in the middle and posteriorly which however, may be absent in pale specimens, head pattern typically with a median brown stripe only (Plate 2).

Distribution- India; South-East Asia; West Malaysia; Java; Sulawesi; New Caledonia [49, 56].

5. Family- Belostomatidae

Subfamily- Lethocerinae

Genus- *Diplonychus* (Laporte, 1833)

Species 1- *Diplonychus rusticus* (Fabricius, 1781): Smaller species, body ovate, length less than 20 mm; body shape more rounded, lateral margins of hemelytra outwardly arcuate; inner margins of eyes convergent anteriorly. Colouration medium brown with lateral margins of pronotum and hemelytra contrasting paler brown. Anterior tarsal claws very small; the ventro - lateral stripe of fine hairs on the abdomen is narrower (Plate 2).

Distribution- India; China; Japan; Java; Malay Peninsula; Myanmar; Pakistan; Phillipines; Sri Lanka; Sumatra; Thailand; New Zealand; New Guinea. [38].

Infra order-Gerromorpha (Semi-aquatic)

6. Family- Mesoveliidae

Subfamily- Mesoveliinae

Genus- *Mesovelia* (Mulsant and Rey, 1852)

Species 1- *Mesovelia vittigera* (Horvath, 1895) : Generally elongate, surface-dwelling bugs; antennae 4 segmented, longer than head; winged forms with ocelli, wind-less forms without ocelli; adult tarsi 3 segmented with apical claws. The species *Mesovelia vittigera* is about 3.3 mm length. Scutellum with 2 black tufts on abdominal sternite VIII (Plate 1).

Distribution- India; Australia; Africa; Malaysia; Palestine; Philippines; Egypt; Indonesia; Samoa Island and Sri Lanka [38].

Species 2- *Mesovelia mulsanti* (White, 1879): fore and mid femura with posterior row of dark spines; male with 2 black tufts on abdominal sternite VIII (Plate 1).

Distribution- India; Brazil; Southern Canada; United States of America; México; Dominican Republic; Puerto Rico; Belize; Bonaire; Grenada; Curaçao; Costa Rica; Panama; Trinidad; Tobago and Hawaii [19, 57, 58, 59, 60, 61, 62, 63, 64, 65].

7. Family- Gerridae

Subfamily- Gerrinae

Genus- *Gerris* (Fabricius, 1775)

Species 1- *Gerris* sp.: Smaller, length ≤ 11 mm; dorsal inner margins of eyes sinuate; pronotum shiny with a single central stripe or no apparent margin; hind tibia not more than 3.2 times length of first tarsal segment (Plate 2).

Distribution- India; China; Indonesia; Myanmar; Nepal; Phillipines; Sri Lanka; Thailand; Vietnam [38].

Genus- *Neogerris* (Matsumura, 1913)

Species 1- *Neogerris* sp.: Dorsal inner margin of eye sinuate; body long and relatively narrow. Pronotum with a central spot (Plate 2).

Distribution- India; Colombia; Trinidad; Tobago; Guyana; Suriname; Brasil; Ecuador; Peru; Bolivia; Paraguay and Argentina [66].

Genus- *Limnognonus* (Stal, 1868)

Species 1- *Limnognonus nitidus* (Myar, 1865): Body length 6.0-8.0 mm; antennae with 1st and 4th segments longest and sub-equal while 2nd and 3rd segments shortest and sub-equal in length; pronotal lobe without yellow median line; connexinum terminating into fairly prominent spine (Plate 2).

Distribution-India; Bangladesh; China; Indonesia; Myanmar; Nepal; Phillipines; Sri Lanka; Thailand; Vietnam [38].

8. Family- Veliidae

Subfamily- Microveliinae

Genus- *Microvelia* (Westwood, 1834)

Species 1- *Microvelia* sp.: Small (body length) surface dwelling bugs with antennae visible from above; ocelli absent. Tarsal claws pre-apical. Last segment of middle leg tarsus not deeply cleft and not bearing plume-like structures. Forelegs with 1 tarsal segment, mid and hind legs each with 2 tarsal segments. Mid tarsi with simple claws in cleft of last segment (Plate 2).

Distribution- India; Indonesia; Japan; Sri Lanka [38].

Order- Odonata

Sub-order- Anisoptera

1. Family- Libellulidae

Subfamily- Leucorrhiniinae

Genus- *Leucorrhinia* (Brittinger, 1850)

Species 1 - *Leucorrhinia* sp.: The length of the cerci is less than half as long as epiproct. Body colour is brown. Eyes larger, more lateral, occupying ½ length of head; lateral spines on abdominal segment 9 about twice length of those on 8 (Plate 2).

Distribution-India; North America [26, 67].

Subfamily- Sympetrinae

Genus- *Neurothemis* (Brauer, 1867)

Species 1 - *Neurothemis* sp.: Paraprocts converge. Eyes protrude anteriorly and laterally. Length of lateral spine on abdominal segments nine shorter than mid-dorsal length of segment. Epiproct not much shorter than paraprocts (Plate 3).

Distribution- Worldwide [68].

Sub-order- Zygoptera

1. Family- Coenagrionidae

Subfamily- Pseudagrioninae

Genus- *Pseudagrion* (Selys, 1876)

Species 1- *Pseudagrion* sp.: Caudal gills shorter than the abdomen; 3 segment of antenna shorter than the second; 3-5 premental setae are usually situated on either side of the midline of the mentum. In *Pseudagrion* sp., posterior corners of head flared; less than 6 palpal setae per labial palp; Caudal gills uniform and rounded at the ends; nodal spine on media caudal gill similar to those on lateral caudal gills (Plate 3).

Distribution- Oriental and Australian region [68].

Subfamily- Ischnurinae

Genus- *Ischnura* (Charpentier, 1840)

Species 1- *Ischnura* sp.: Antennae without a distinct apical spine at the 4th flageller segment. Caudal lamellae broader in the middle, with apices sharply pointed (Plate 3).

Distribution- Cosmopolitan [69].

Order- Coleoptera

Suborder- Adephaga

1. Family- Dytiscidae

Subfamily- Laccophilinae

Genus- *Laccophilus* (Leach, 1817)

Species 1- *Laccophilus* sp.: Adult Dytiscidae range from about 1 to 40 mm in length. They are shiny, usually black or brownish- black, but often marked with dull yellow, green, or bronze. The antennae have 11 segments and are long and threadlike. The second and third legs are widely separated owing to the very large hind coxae. . In *Laccophilus* sp., the spines of hind tibiae divided at tip; usually 3 to 6 mm long; widely distributed and common (Plate 2).

Distribution-India; Nepal; Sri Lanka; Myanmar; China; Japan; Vietnam; Combodia; Laos; Malaysia; Bangladesh and Northern Thailand [70].

Suborder- Adephaga

2. Family- Gyrinidae

Subfamily- Gyrininae

Genus- *Dineutus* (Macleay, 1825)

Species 1- *Dineutus* sp. Adults are distinguished by the larger size (> 8 mm); dorsal and ventral compound eyes widely separated; nonpubescent pronotum and elytra; concealed scutellum; elytra smooth or with weak, indistinct striae; and last two abdominal sternites without a median longitudinal row of setae (Plate 3).

Distribution- India; North America; Florida; Australia [41, 71, 72].

Suborder- Polyphaga

3. Family- Hydrophilidae

Subfamily- Hydrophilinae

Genus- *Berosus* (Leach, 1817)

Species 1 - *Berosus* sp.: Adults are distinguished by the moderately small size (2-7) and brown to yellowish –brown coloration; pronotum not continuous in outline with elytra; scutellum longer than wide; meso and metasternum without a ventral keel produced into a posterior spine; and middle and hind tibiae and tarsi with well developed fringe of long natatory setae, basal tersomere shorter than second (Plate 3).

Distribution- Found worldwide [73, 74].

Genus- *Laccobius* (Erichson, 1837)

Species 1- *Laccobius* sp. Adults are distinguished by the small size (< 4 mm); maxillary palpi shorter than antennae; elytra without striae; arcuate hind tibiae; 5 segmented tarsi, mid and hind tarsi with natatory setae (Plate 3).

Distribution-India; Nepal; China; North Korea; Russia; Kyrgyzstan; Tadzhikistan; Afghanistan; Pakistan; Bhutan; Burma; Laos; Vietnam [75].

4. Family- Curculionidae
 Subfamily- Dryophthorinae
 Genus- *Sphenophorus* (Schoenherr, 1838)

Species 1- *Sphenophorus* sp.: Antennal club with 2 apparent segments; apical one spongy, basal one globrous; funicle with 6 segments (Plate 3).

Distribution- New World distribution from Mexico to Panama [76, 77, 78].

Subfamily- Eriirhininae
 Genus- *Neochetina* (Hustache, 1926)

Species 1- *Neochetina* sp.: Venter with 3 well developed tubercles behind/between fore coxae and tubercle between mid coxae (Plate 3).

Distribution- India; Florida [28, 41].

5. Family- Chrysomelidae
 Subfamily- Donaciinae
 Genus- *Donacia* (Fabricius, 1775)

Species 1- *Donacia* sp.: Prothorax laterally rounded, without a definite lateral margin. Apex of elytron round, truncate or at most produced to a sharp angle, but without a long spine. Inner carina of elytra extending to apex (Plate 3).

Distribution- India; Myanmar; Thailand; Vietnam; Laos; Cambodia; Peninsular Malaysia; Borneo; Sumatra; Java; Lombok; Sulawesi and Florida [41, 79].

Order- Ephemeroptera

1. Family- Baetidae
 Subfamily- Cloeoninae
 Genus- *Cloeon* (Leach, 1815)

Species 1- *Cloeon* sp. Meta thoracic wing pad present; the smaller lamella on the dorsal surface of the gill (Plate 4).

Distribution- Found Worldwide [80, 81].

Order- Diptera

1. Family- Chironomidae
 Subfamily- Chironominae
 Genus- *Chironomus* (Megien, 1803)

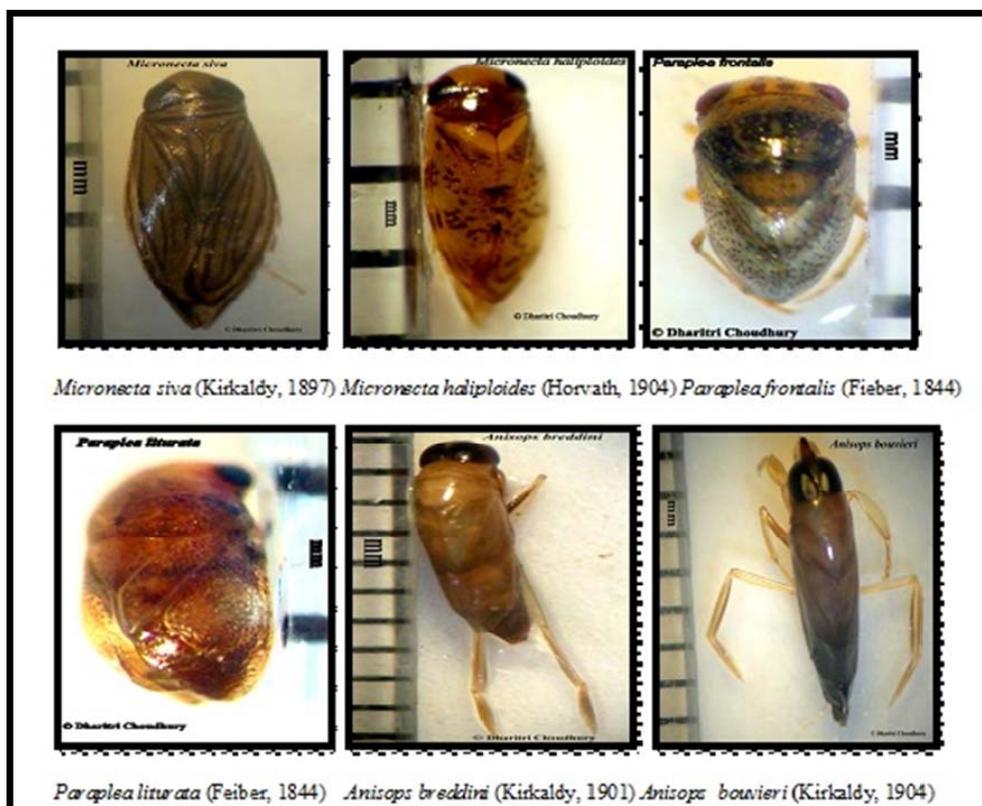
Species 1- *Chironomus* sp. (Larva): Two eyespots usually separate and arranged one above the other. Eighth abdominal segment with fingerlike ventral tubules, body length usually less than 30 mm. Ventral tubules shorter than length of eighth abdominal segment. Seventh abdominal segment without posterolateral tubules, lentic habitat (Plate 4).

Distribution- Found worldwide [82, 83].

2. Family- Culicidae
 Subfamily- Culicinae
 Genus- *Culex* (Linnaeus, 1758)

Species 1- *Culex* sp. (Larva): Head without prominent lateral pouches. Respiratory siphon with several pairs of hair tufts (Plate 4).

Distribution- India; China; most of pan and subtropical part of America; Neotropics; Indomalaysia; Australia; United Kingdom; Middle East and Eastern Asian regions of the world [84, 85, 86, 87, 88, 89].



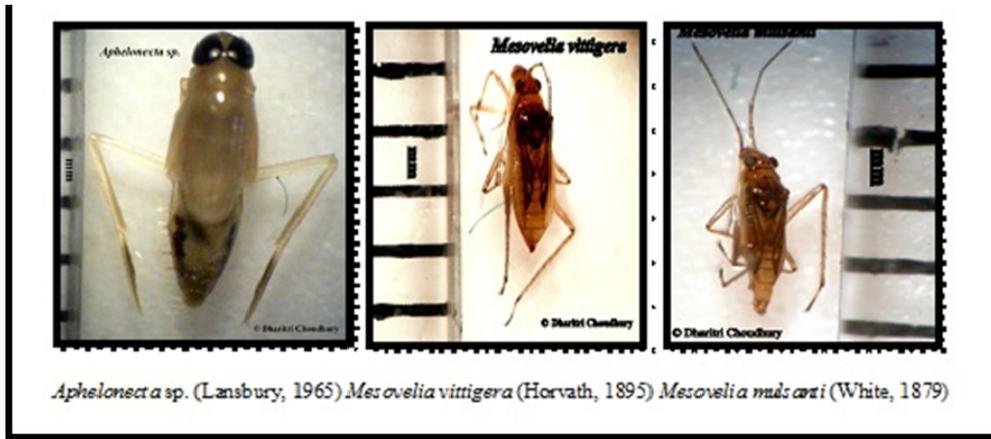


Plate 1: Images of *Micronecta siva*, *Micronecta haliploides*, *Paraplea frontalis*, *Paraplea liturata*, *Anisops breddini*, *Anisops bouvieri*, *Aphelonecta* sp. and *Mesovelia vittigera* and *Mesovelia mulsanti*.

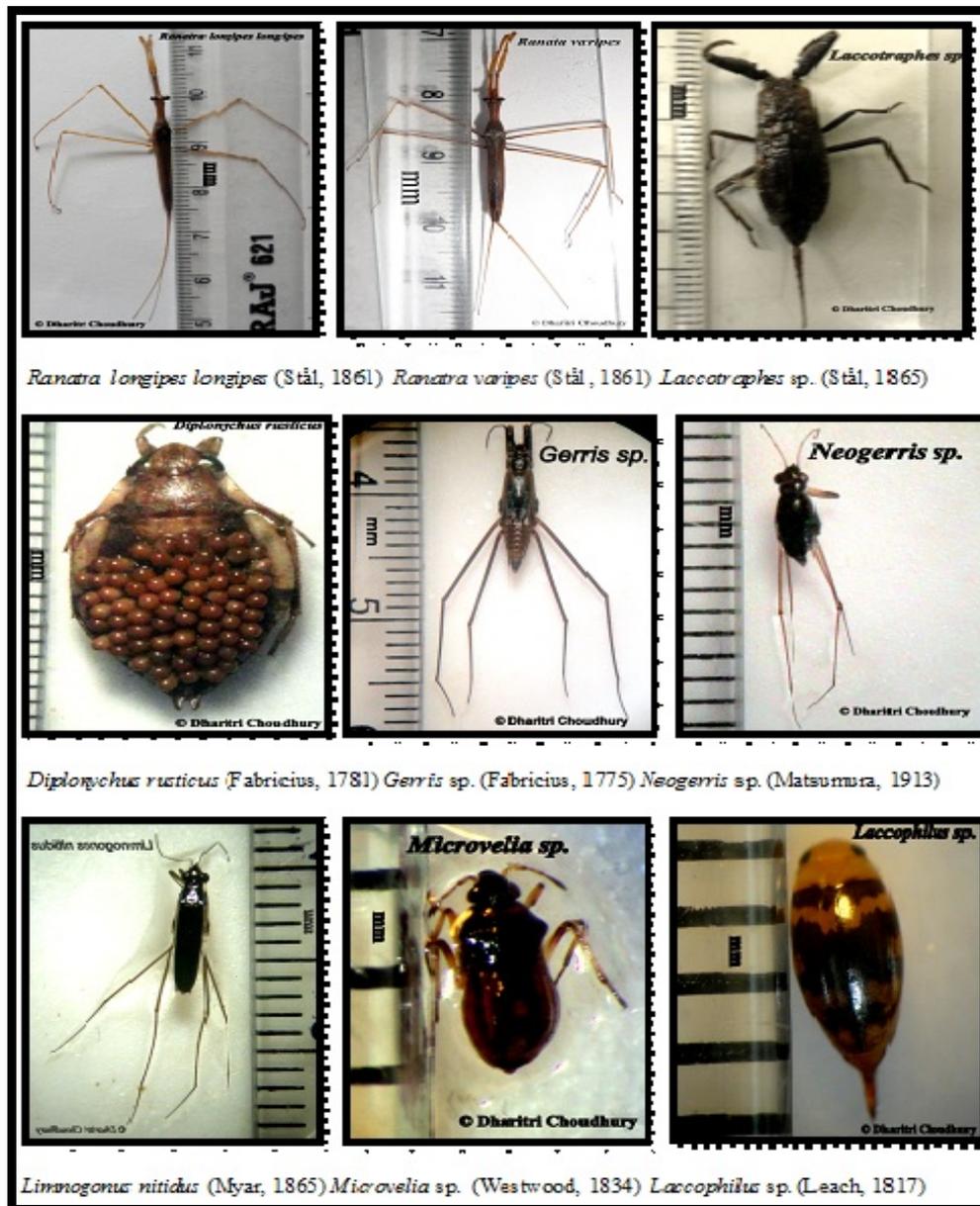


Plate 2: Images of *Ranatra longipes longipes*, *Ranatra varipes*, *Laccotraphes* sp., *Diplonychus rusticus*, *Gerris* sp., *Neogerris* sp., *Limnogonus nitidus*., *Microvelia* sp. and *Laccophilus* sp.

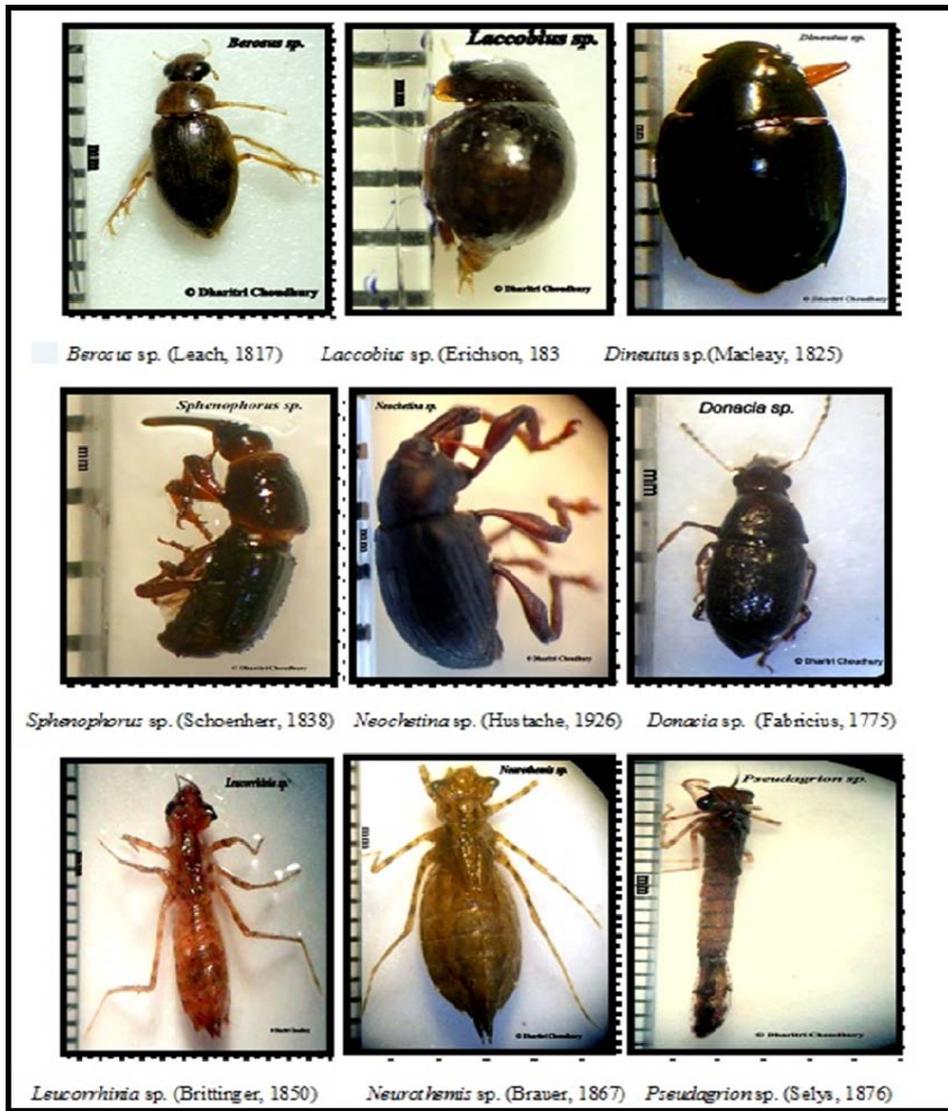


Plate 3: Images of *Berosus sp.*, *Laccobius sp.*, *Dineutus sp.*, *Sphenophorus sp.*, *Neochetina sp.*, *Donacia sp.*, *Leucorrhinia sp.*, *Neurothemis sp.* and *Pseudagrion sp.*



Plate 4: Images of *Ischnura sp.*, *Chironomus sp.*, *Culex sp.* and *Cloeon sp.*

4. Conclusions

This study revealed that the Lake Deepor beel is a rich aquatic system although encountering anthropogenic disturbances. There is scanty information on the abundance and diversity of aquatic insects in freshwater bodies in Assam. Therefore, it is imperative to make continuous investigation, censuses and research activities on the taxonomy and diversity of aquatic insects, so that knowledge regarding this important group can be utilized by future researchers as baseline data for further research and conservation planning.

5. Acknowledgements

Authors are thankful to the Head of the Department of Ecology and Environmental Science, Assam University, Silchar, India for providing laboratory facilities. The first author is eternally grateful to the Department of Science and Technology (DST), New Delhi for funding this research through INSPIRE Fellowship under INSPIRE Program.

6. References

- Dunbar MJ, Warren M, Extence C, Baker L, Cadman D, Mould DJ *et al.* Interaction between macroinvertebrates, discharge and physical habitat in upland rivers. *Aquatic Conservation and Marine and Freshwater Ecosystem* 2010; 20:31-44.
- Minshall GW. Responses of stream benthic macroinvertebrates to fire. *Forest Ecology and Management* 2003; 178:155-161.
- Tachet H, Richoux P, Bournaud M, Usseglio-Polatera P. *Invertébrés d'eau douce: systématique, biologie, écologie.* CNRS Edn, Paris, 2003, 587.
- Mittermeier RA, Fonseca Da GAB, Rylands AB, Mittermeier CG. In: Mittermeier RA, Robles GP, Mittermeier CG. *Megadiversity: Earth's Biologically Wealthiest Nations.* Edn, CEMEX, Monterrey, Mexico, 1997, 39-49.
- WCMC. *Freshwater Biodiversity: A preliminary Global Assessment.* A document prepared for the 4th Meeting of the Conference of the Practices to the convention of Biological Diversity, World Conservation Monitoring Centre, 1998.
- Sivaramakrishnan KG, Job SV. Studies on mayfly populations of Courtallam streams. *Proceedings of a Symposium on Ecology of Animal Populations, Zoological Survey of India, Calcutta, 1981, 105-116.*
- Sivaramakrishnan KG, Venkataraman K, Sridhar S, Marimuthu M. Spatial patterns of benthic macroinvertebrate distributions along river Kaveri and its tributaries (India). *International Journal of Ecology and Environmental Sciences* 1995; 21:141-161.
- Sivaramakrishnan KG, Morgan HJ, Vincent RH. Biological assessment of the Kaveri river catchment, South India, and using benthic macroinvertebrates: Applicability of water quality monitoring approaches developed in other countries. *International journal of Ecology and Environmental Science* 1996; 32: 113-132.
- Thirumalai G. In: *Aquatic and semi-aquatic heteroptera of India.* Indian Association of Aquatic Biologists Hyderabad 1999; 7:74.
- Sivaramakrishnan KG, Venkataraman K, Moorthy RK, Subramanian KA, Utkarsh G. Aquatic insect diversity and ubiquity of the streams of the Western Ghats, India. *Journal of the Indian Institute of Science* 2000; 80:537-552.
- Anbalagan S, Kaleeswaran B, Balasubramanian C. Diversity and Trophic categorization of aquatic insects of Courtallam hills of Western Ghats. *Entomon* 2004; 29:1-6.
- Subramanian KA, Sivaramakrishnan KG. Habitat and microhabitat distribution of stream insect communities of the Western Ghats. *Current Science* 2005; 89:976-987.
- Anbalagan S, Dinakaran S. Seasonal variation of diversity and habitat preferences of aquatic insects along the longitudinal gradient of the Gadana river basin, South-West Ghats (India). *Acta Zoologica Bulgarica* 2006; 58:253-264.
- Dinakaran S, Anbalagan S. Anthropogenic impacts on aquatic insects in six streams of south Western Ghats. *Journal of Insect Science* 2007; 7:1-7.
- Dinakaran S, Balachandran C, Anbalagan S. Relative influence of environmental variables on blackfly assemblages in streams of Nilgiri hills of southern Western Ghats, India. *Journal of Aquatic Biology* 2009; 24:21-25.
- Selvakumar C, Sundar S, Arunachalam M. Diversity and Distribution of Mayflies (Insecta: Ephemeroptera) in Tamirabarani River of Southern Western Ghats, India. *International Journal of Applied Bioresearch* 2012; 5:1-7.
- Abhijna UG, Ratheesh R, Biju Kumar A. Distribution and diversity of aquatic insects of Vellayani lake in Kerala. *Journal of Environmental Biology* 2013; 34:605-611.
- Majumdar TN, Gupta A. Aquatic insects in the lentic systems of North Cachar Hills, Assam, India. *Journal of Current Sciences* 2005; 7:219-224.
- Das K, Gupta S. Aquatic Hemiptera Community of Agricultural Fields and Rain Pools in Cachar District, Assam, North East India. *Assam University Journal of Science & Technology: Biological and Environmental Science* 2010; 5:123-128.
- Das K, Gupta S. Seasonal variation of Hemiptera community of a temple pond of Cachar District, Assam, northeastern India. *Journal of Threatened Taxa* 2012; 4:3050-3058.
- Hazarika R, Goswami MM. Aquatic Hemiptera of Gauhati University. Guwahati, Assam, India, *Journal of Threatened Taxa* 2010; 2:778-782.
- Takhelmayum K, Gupta S. Diversity of aquatic insect in Loktak Lake (Ramsar Site), Manipur, North-East India with reference to environmental variables. *Proceeding of International Conference on Biodiversity & Aquatic Toxicology* 2011a, 50-58.
- Takhelmayum K, Gupta S. Distribution of aquatic insects in phumdis floating island of Loktak lake, Manipur, northeastern India. *Journal of Threatened Taxa* 2011b; 3:1856-1861.
- Takhelmayum K, Gupta S, Singh NR. Diversity and Density of Aquatic Insects in the Lower Reach of River Moirang, Manipur, North East India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 2013, 1-12.
- Gupta S, Narzary R. Aquatic Insect Community of lake, Pulbari anua in Cachar, Assam. *Journal of Environmental Biology* 2013; 34:591-597.
- Takhelmayum K, Gupta S. Odonata larvae of Keibul Lamjao National Park, Manipur, Northeastern India. *Journal of Threatened Taxa* 2014; 6(6):5858-5863.
- Chetri G, Sheikh MS, Kalita J, Dutta. A Population abundance of aquatic insects in Deepar Beel Assam. *Insect Environment* 1997; 3:14-15.
- Kalita G. Ecology & Distribution of macroinvertebrate enmeshed fauna in Deepar wetland of Assam, India. Ph. D Thesis. Gauhati University, Guwahati, Assam., India,

- 2008.
29. IUCN. Directory of Asian Wetlands. Published by IUCN Participating Organizations with collaboration of IUCN, IWRB, ICBP and WWF-International, Oxford University press, Oxford, 1987.
 30. Government of Assam. The Assam Gazette. PART HA, published by Secretary to the Government of Assam Forest Department, March 22, 1989, 247-250.
 31. Islam MZ, Rahmani AR. Important Bird areas in India: Priority sites conservation. Indian Bird conservation network: Bombay Natural History Society and Bird life International (UK), 2004, Xviii+1133.
 32. Brittain JE. Studies on the Lentic Ephemeroptera and Plecoptera of Southern Norway. Norsk Entomologisk Tidsskrift 1974; 21:135-151.
 33. Macan TT, Maudsley R. The Insects of the Stony Substratum of Windermere. Transactions of the Society for British Entomology 1968; 8:1-18.
 34. Pennak RW. Fresh-Water Invertebrates of the United States. Edn 2, John Wiley and Sons, New York, 1978, 803.
 35. Edmondson WT. Fresh water Biology. Edn 2, University of Washington, Seattle, 1992, 908-1023.
 36. Westfall JMJ, May ML. Damselflies of North America. Scientific Publishers, Gainesville, Florida, 1996, 65.
 37. Richardson JS. Identification Manual for the Dragonfly Larvae (Anisoptera) of Florida, 2003, 1-112.
 38. Bal A, Basu RC. Insect: Hemiptera: Water-Bugs. State Fauna Series 10, Fauna of Manipur, Zoological Survey of India, India, 2004, 293-310.
 39. Neiser N, Chen P. The Water Bugs (Hemiptera: Nepomorpha and Gerromorpha) of Vanuatu. Tijdschrift voor Entomologie 2005; 148:307-327.
 40. Epler JH. Identification manual for the aquatic & semi aquatic heteroptera of Florida. Florida Department of Environmental Protection Tallahassee, Florida, 2006, 1-195.
 41. Epler JH. The Water Beetles of Florida. Florida Department of Environmental Protection Tallahassee, Florida, 2010, 1-414.
 42. Neesemann HR, Shah DT, Shah DN. Key to the larval stages of common Odonata of Hindu Kush Himalaya, with short notes on habitats and ecology. Journal of Threatened Taxa 2011; 3:2045-2060.
 43. Polhemus DA, Polhemus JT. Guide to the aquatic Heteroptera of Singapore and Peninsular Malaysia. x. Infraorder Nepomorpha—families Belostomatidae and Nepidae. The Raffles Bulletin of Zoology 2013; 61:25-45.
 44. Deepa J, Rao CAN. Aquatic Hemiptera of Pocharam Lake, Andhra Pradesh. Zoos' Print Journal 2007; 22:2937-2939.
 45. Bhattacharya DK. Insect fauna associated with large water hyacinth in freshwater wetlands of West Bengal. Biodiversity and Environment, Proceedings of the National Seminar on Environmental biology, Daya Publishing House, Delhi, 1998, 145-147.
 46. Khan RA. Diversity of freshwater macro-invertebrate communities associated with macrophytes. Records of Zoological Survey of India 2002; 100:211-228.
 47. Nieser N, Chen P. Sixteen new species of Nepomorpha (Heteroptera) mainly from Sulawe (Indonesia). Tijdschrift voor Entomologie 1999; 142:77-123.
 48. Leong CY. A taxonomic study of the Malayan Corixidae (Hemiptera-Heteroptera) with the description of *Micronecta malayana* sp. nov. novo Bulletin of the National Museum Singapore 1966; 33: 83-90.
 49. Fernando CH, Cheng L. A preliminary study on the fauna and distribution of aquatic Hemiptera in Malaya and Singapore. Federation Museums Journal 1974; 19:21-44.
 50. Stål C. Nova methodus familias quasdam Hemipt. disponendi. Öfversigt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar 1861; 18:203.
 51. Lundblad OM. Zur Kenntnis der aquatilen und semiaquatilen Hemipteren von Sumatra, Java und Bali. Archiv für Hydrobiologie Supplement Band 1933; 12: 1–195, 263-488, pls.1–21.
 52. Lansbury I. A review of the Oriental species of *Ranatra* Fabricius (Hemiptera–Heteroptera: Nepidae). Transactions of the Royal Entomological Society of London 1972; 124:287-341.
 53. Nieser N, Chen P. Naucoridae, Nepidae and Notonectidae, mainly from Sulawesi and Pulau Buton (Indonesia). Tijdschrift voor Entomologie 1991; 134:47-67.
 54. zsienviis.nic.in/biodiversity wb/Fauna/21.%20Hemiptera.doc.
 55. Fernando CH, Leong CY. A taxonomic study of the Malayan Notonectidae (Hemiptera: Heteroptera). Indian Journal of Zoology 1976; 4:15-34.
 56. Nieser N. Guide to aquatic Heteroptera of Singapore and Peninsular Malaysia iii. Pleidae and Notonectidae. The Raffles Bulletin of Zoology 2004; 52:79-96.
 57. Uhler PR. On the Hemiptera - Heteroptera of the Island of Grenada, West Indies. Proceedings of the Zoological Society of London 1894; 1894:167-224.
 58. Blatchley WS. Heteroptera or True Bugs of Eastern North America with Especial Reference to the Faunas of Indiana and Florida. The Nature Publishing Company, Indianapolis, 1926, 1-1116.
 59. Herring JL. The aquatic and semiaquatic hemiptera of Northern Florida, Part 2: Veliidae and Mesoveliidae. The Florida Entomologist 1950; 33:145-150.
 60. Harris HM, Drake CJ. Notes on the family Mesoveliidae (Hemiptera) with descriptions of two new species. Iowa State College Journal of Science 1941; 15:275-277.
 61. Hungerford HB. Concerning *Mesovelia douglaensis* Hungerford. Journal of the Kansas Entomological Society 1953; 26:76-77.
 62. Polhemus JT, Chapman HC. Family Mesoveliidae/water treader. In: Menke AS. The Semiaquatic and Aquatic Hemiptera of California (Heteroptera: Hemiptera). Edn, Bulletin of the California Insect Survey 1979; 21:39-42.
 63. Andersen NM, Polhemus JT. Four new genera of Mesoveliidae (Hemiptera, Gerromorpha) and the phylogeny and classification of the family. Entomologica Scandinavica 1980; 11:369-392.
 64. Spangler PJ. A new species of Halophilous water-strider, *Mesovelia polhemusi*, from Belize and a key and checklist of the New World species of the genus (Heteroptera: Mesoveliidae). Proceedings of the Biological Society of Washington 1990; 103:86-94.
 65. Bass D. A survey of freshwater macroinvertebrates in Tobago. Living World, Journal of Trinidad and Tobago Field Naturalists' Club 2003; 2003: 64-69.
 66. Moreira FFF, Ribeiro JRI, Nessimian JL, Itsyama MM, Castanhole MMU, Pereira LLV. New records and distribution expansions for Neotropical water striders (Insecta: Heteroptera: Gerromorpha). Check List (Journal of species lists and distribution) 2011; 7:1-7.
 67. Steinmann H. World Catalogue of Odonata (Anisoptera). Das Tierreich. The Animal Kingdom. Vol. 2, Part-3, Walter de Gruyter, Berlin, New York, 1997, 636.
 68. Subramanian KA. Dragonflies and Damselflies of

- Peninsular India-A Field Guide. Project Lifescape. Indian Academy of Sciences, Bangalore, India, 2005, 118.
69. Machado ABM. A new species of *Ischnura* (Odonata: Coenagrionidae) from high altitude eastern Andes, of Colombia. *Zoologica* 2012; 29:598-600.
 70. Hájek J, Štátný J. Two new species of *Laccophilus* Leach, 1815 (Coleoptera: Dytiscidae) from India and Borneo with notes on other species of the genus. *Acta Entomologica Musei Nationalis Pragae* 2005; 45:51-58.
 71. Watts CHS, Hamon H. Pictorial Guide to the Australian Whirligig Beetles. Entomology Department, South Australian Museum, Adelaide, South Australia, 2010, 1-27.
 72. Jaiswal D. Checklist of aquatic Coleoptera of India. Freshwater Biology Regional Centre, Zoological Survey of India, India, 2010, 1-17.
 73. Hansen M. World Catalogue of Insects. Hydrophiloidea (Coleoptera). Vol. 1, Aps. Stenstrup, Apollo Books, Copenhagen, 1999, 416.
 74. Löbl I, Smetana A. Catalogue of Palearctic Coleoptera. Hydrophiloidea- Staphylinoidea. Vol. 2, Apollo Books, Copenhagen, 2004, 942.
 75. Gentili E. Hydrophilidae: 3. The genus *Laccobius* ERICHSON in China and neighbouring areas (Coleoptera). In: Jach MA, Ji L. Water Beetles of China, (Edn.), 1995; 1:245-286.
 76. Champion GC. Insecta. Coleoptera, Rhynchophora. Curculionidae. Curculioninae (concluded) and Calandrinae. *Biologia Centrali-Americana* 1909; 4(7): 221.
 77. Vaurie P. Revision of the genus *Calendra* (formerly *Sphenophorus*) in the United States and Mexico (Coleoptera, Curculionidae). *Bulletin of the American Museum of Natural History* 1951; 98:29-186.
 78. Anderson RS. The Dryophthoridae of Costa Rica and Panama: checklist with keys, new synonymy and descriptions of new species of *Cactophagus*, *Mesocordylus*, *Metamasius* and *Rhodobaenus* (Coleoptera: Curculionidae). *Zootaxa* 2002; 80:1-94.
 79. Mahammed SM. Chrysomelidae of the Lesser Sunda Islands: Wallace's Line and the crossing of Worlds. In: Jolivet P, Santiago-Blay J, Schmitt M. Research on Chrysomelidae. Edn, Vol.2, Brill, Hotei Publishing, IDC Publishers, Martinus Nijhoff Publishers and VSP, The Netherlands, 2009, 69-85.
 80. Gupta A, Gupta S, Michael RG. Seasonal abundance and diet of *Cloeon* sp. (Ephemeroptera: Baetidae) in a northeast Indian lake. *Archive of Hydrobiology* 1994; 130:349-357.
 81. Salles FF, Gattolliat JL, Angeli KB, De-Souza MR, Gonçalves IC, Nessimian JL *et al.* Discovery of an alien species of mayfly in South America (Ephemeroptera). *ZooKeys* doi:10.3897/zookeys.399.6680 2014; 399:1-16.
 82. Stevens MM. Biology and control of *Chironomus tepperi* Skuse, A pest of rice in New South Wales. In: Cranston P. S. Chironomids from gene to ecosystem. Edn, The Commonwealth Scientific and Industrial Research Organisation, Australia, 1995, 235-239.
 83. Stevens MM, Fox KM, Warren GN, Cullis BR, Coombes NE, Lewin LG. An image analysis technique for assessing resistance in rice cultivars to root feeding chironomid midges (Diptera: Chironomidae). *Field Crop Research* 2000; 66:25-36.
 84. Das BP, Lal S, Saxena VK. Outdoorresting preference of *Culex tritaeniorhynchus*, the Vector of Japanese encephalitis in Warangal and Karim Nagar districts, Andhra Pradesh. *Journal of Vector Borne Disease* 2004; 41:32-36.
 85. Ji-Guang M, Mei X. Progress in studies on the overwintering of the mosquito *Culex tritaeniorhynchus*. *Southeast Asian Journal of Tropical Medicine and Public Health* 1996; 27:810-817.
 86. Weinstein P, Laird M, and Browne G. Exotic and endemic mosquitoes in New Zealand as potential arbovirus vectors. Wellington, Ministry of Health, 1997.
 87. White GB. Notes on a catalogue of Culicidae of the Ethiopian region. *Mosquito Systematics* 1975; 7:303-344.
 88. Lee DJ, Hicks MM, Debenhan ML, Griffiths M, Marks EN, Bryan JH, Russell RC. The Culicidae of the Australian region. Vol.7, No. 2, Australian Government Publishing Service, Canberra, 1989, 1-281.
 89. Bram RA. Contributions to the mosquito fauna of Southeast Asia (Diptera Culicidae) II. The genus *Culex* in Thailand. *Contributions of the American Entomological Institute* 1967; 2:1-296.